



Pest Risk Analysis on Karnal Bunt

Pest: Tilletia indica (Neovossia indica)

Disease: Karnal Bunt (Partial Bunt)

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Commodity: Wheat – Rye

Domestic Concern: Wheat – Rye

File No: 3

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Origin: Possible Introduction

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I. Summary of Life Cycle, Distribution, and Epidemiology

Teliospores, the thick-walled overwintering spores, persist in soil and in or on kernels. Seed contaminated with teliospores can introduce the pathogen to new areas. In response to moisture in the spring, the teliospores germinate and develop spore-bearing structures (promycelia). If cool, wet weather occurs during flowering, air currents and splashing water will carry thin-walled spores (primary and secondary sporidia) to the host plants to initiate infections. The infections lead to partial or complete conversion of developing kernels into darkened masses of teliospores. At harvest bunted kernels liberate spores that contaminate soil and seed (Wiese, 1977; Warham, 1986).

II. Hosts

The following are hosts.

Scientific Name	Common Name	Reference
<u>Triticum aestivum</u>	Wheat	Joshi et al, 1983
<u>Triticum durum</u>	Durum wheat	“
<u>Triticale hexaploide</u>	Triticale	“
<u>Secale cereale</u>	Rye	Warham, 1988
<u>Triticum</u> spp.	Wild species of wheat	Singh, 1986
<u>Aegilops</u> spp.	Goatgrass	Warham et al, 1986

III. Dissemination/Vectors

Literature:

According to Smilanick and coworkers (1986), germination of teliospores ingested by leghorn chickens was 46% of uningested controls; germination of teliospores ingested by grasshoppers, Melanoplus sanguinipes, was 70% of uningested controls. Although reduced by ingestion by potential vectors, teliospore germination remained at a high level.

After burning of infected wheat fields, viable teliospores were collected below and at the 3,000 m altitude (Bonde, 1987); it is possible that these teliospores will be transported several hundred miles (Schall, 1988).

Discussion:

Viable teliospores could be widely disseminated by the natural movement of grain-eating migratory animals and by the importation and use of bunt-contaminated, animal-derived fertilizers. It is a common practice to feed severely bunt-contaminated grain to feedlot animals; in this case, application of manure from the feedlot animals would deposit teliospores on the soil surface in a manner conducive to natural infection of wheat. In addition, teliospores could also be transported over long distances by air currents. Finally, teliospore-contaminated harvesting equipment, barges, and transportation equipment could transport the pathogen.

IV. Rating Elements of Risk Model

Probability of Establishment

Estimate probability of pest being on, with, or in the plant commodity during import.

High

Literature:

Where the pathogen is established in favorable areas in India, there is a high prevalence of infected samples in favorable years; for example, the percentage of infested wheat samples from threshing floors was 93.1% in the State of Punjab in 1980 (Singh et al, 1983). In Mexico in the May and Yaqui Valleys where the pathogen was introduced in the 70's, 6% and 64% of the samples collected were infected in 1982 and 1983, respectively (Warham, 1986).

Newly-formed teliospores generally have a dormant period of 6-8 months (Zhang et al, 1984). Afterwards, if under suitable conditions, the teliospores will be capable of germinating for years. When bunted grains were stored in a laboratory refrigerator at 10 C, the teliospores survived for more than 5 years. At the 5-year mark, germination was approximately 4%. When bunted grains were stored at room temperature (17-33 C), the teliospores retained their viability for 4.5 years. At the 4.5-year mark, germination was approximately 2% (Krishna and Singh, 1983).

Discussion:

Where Karnal bunt occurs, there will be years in which a high percentage of the grain will be infected. Therefore, because of (1) infection of kernels in the field, (2) contamination of uninfected kernels during harvest, and (3) contamination of pathogen-free grain in contaminated grain-handling facilities, the grain from infested regions is likely to be contaminated.

If the grain is contaminated, teliospores are likely to survive for long periods under typical storage conditions.

**Estimate probability of pest surviving in transit and successfully
passing undetected at ports of entry. *High***

Literature:

If at 10 C or at room temperature, the teliospores will survive transit easily (Krisna and Singh, 1983).

Teliospores can survive 10 weeks of deep freezing (-18 C), although germination is almost totally inhibited. One week of deep freezing had no adverse effect; 2 weeks decreased the germination by half (Zhang et al, 1984),. Scientists at the USDA Foreign Disease – Weed Science Research Unit in Frederick, MD found that freezing for two months did not significantly inhibit germination (Matt Royer – personnel communication).

Some kernels are completely infected, but most are partially infected; therefore, visual examination may not detect a low level presence (Warham, 1990).

Only specialized tests, such as the glycerol filtration seed assay, will detect trace amounts of teliospores contaminating wheat seed (Matsumoto and Bell, 1969; Warham, 1986).

Discussion:

The teliospores are capable of surviving the temperature extremes usually encountered during transit.

Partially infected kernels, particularly if few in number, could easily escape detection.

Although fully and partially bunted kernels, if present in significant numbers, could be detectable by visual inspection, kernels contaminated with trace amounts of teliospores would probably pass visual inspection at ports of entry. Only specialized tests, such as the glycerol filtration seed assay, will detect trace amounts of teliospores in wheat seed.

Estimate probability of pest successfully colonizing. *High*

Literature:

First found in the State of Haryana, India, the disease is present across northern India from the western border to Bihar and West Bengal. The KB pathogen also occurs in Afghanistan, Iraq, Pakistan, Mexico, and Nepal (Joshi et al, 1983; Royer and Rytter, 1985; Singh and Agaral, 1989). The occurrence in Afghanistan is not mentioned in some publications (Waller and Mordue, 1983). Lambat (1983) considers the pathogen to be established in Lebanon, Syria, and Turkey in the Middle East; however, this is based on the examination of wheat germplasm seed packets.

Walter (1973) divides the world into nine main climate zones. The KB pathogen is established in several main climate zones and transitional zones.

Climate Zone	Title	Climate Zone Characteristics	Geographical Area
II.	Tropical	Rainy season in summer; Dry season in the cool months	India
III.	Subtropical Dry	Rainfall is very low; daytime temperatures are very high	Iraq, N. Mexico
II-III.	Trans. Zone		S. Pakistan
IV-II.	Trans. Zone		N. Pakistan
VII-IV.	Trans. Zone		Afghanistan

Based on the ability of the teliospores to survive freezing temperatures (Smilanick et al, 1985; Zhang et al, 1984), it is probable that the KB pathogen can survive in at least the Warm Temperate (V) and possibly the Typical Temperate (VI) Zone.

V.	Warm Temperate	scarcely any or no winter, extremely wet, exp. In summer	Southeastern U.S.
VI.	Typical Temperate	Winters are cold but not long, summers are cool when oceanic	Northeastern U.S.
VII.	Arid Temperate	Continental climate; little precipitation	Great Plains

According to Zhang and coworkers (1984), the teliospores can survive 10 weeks of deep freezing with real difficulty and freezing and thawing at lower temperatures with some difficulty. Therefore, Zhang feels that Warm Temperate (Zone V) early-ripening winter-wheat area in the Yangtze River Valley in China is at high risk. In this Warm Temperate region the winters are generally short, with an average temperature between -5 and $+5$ C. Furthermore, the weather in this area is predominately cloudy and rainy during the wheat flowering period. Zhang also feels that the Typical Temperate (Zone VI) winter-wheat area in the Yellow River Valley is at moderate risk.

According to Schall (1988), there are large wheat-growing areas of the Southwest that appear to be favorable environments at the risk to the establishment of the KB pathogen. These high-risk wheat-growing areas are: the white wheat area of Arizona (Zone III); the white wheat area of California (Zone III/Zone IV); and the hard and soft red winter wheat areas of New Mexico and Texas (Zone VII-III).

Although the levels of susceptibility vary greatly, no line or cultivar of bread wheat is immune. Durum wheat is slightly less susceptible than bread wheat; triticale is less susceptible than durum wheat (Warham, 1988).

Discussion:

The potential for the pathogen to occupy several extensive portions of wheat-growing areas is large. The general consensus appears to be that at least the southern portions of the soft red winter, hard red winter, and white wheat-growing areas are at risk.

Estimate probability of pest to spread beyond the colonized area.

High

Literature:

The spread of Karnal bunt to different ecological zones on the Indian subcontinent and its appearance in other geographical areas of the world indicates that the pathogen possesses great adaptability to different climatic conditions (Zhang et al, 1984).

Discussion:

The ability of the pathogen to be disseminated by wind, vectors, and contaminated seed (Page 1) favors the spread of the pathogen beyond the colonized area.

Consequence of Establishment

Estimate economic impact if established.

High

Literature:

The following tables are from "Agricultural statistics 1989"

Table 554.

Crops: Area, yield, production, and value, US 1988.

Crop Production	Area Harvested	Production	Value of
	1,000 Acres	Thousands Bu	1,000 Dollars
Corn for grain	58,164	4,921,191	13,011,192
Rye	607	15,047	37,027
Soybeans	57,383	1,538,666	11,864,842
Wheat, all	54,174	1,811,261	6,632,805
Winter	39,785	1,560,970	5,627,206
Durum	2,847	44,831	218,625
Other spring	10,542	205,460	786,974

Table 690.

U.S. agricultural exports: Value of exports year ending Sept. 30, 1988.

Total Agricultural Exports (Million Dollars)			
	Under specified Government Prog.	Outside Specified Government Prog.	Total
Corn	118.1	4,219.9	4,338.0
Soybeans	5.4	5,002.6	5,008.0
Wheat	619.5	3,847.4	4,466.9
Wheat flour	96.6	74.7	171.3
Bulgar wheat	49.0	-22.5	26.5
Total (all Commodities)	1,521.9	33,812.4	35,334.3

Table 14.**Wheat and flour: International trade, 1988**

	1,000 Metric Tons	
	Exports	Imports
Principal exporters		
United States	38,000	600
France	18,500	200
Canada	13,500	0
Australia	20,700	0
Argentina	3,500	0

Table 14.**Wheat and flour: International trade, 1988**

Principal importers		
Soviet Union	500	15,500
China	0	15,500
Egypt	0	6,400
Italy	3,600	5,500
Japan	360	5,200

Losses in yield overall may be limited. Even during the worst epidemic years in India, 1978-79 and 1980-81, the total damage to the crop was only 0.2 to 0.5% of the total production (Singh et al, 1983). Other sources report losses of 5 to 20% with the most severe incidences (Warham, 1986).

In individual fields or plots, severity of infection can be very high, in some fields as many as 89% of the kernels were infected (Joshi et al, 1983).

Royer and Datnoff (1987) estimated that bunted kernels were reduced 0.33% in weight.

The level of infection that affects the quality of bread products is controversial. Some researchers report that wheat lots with even 1% infected kernels reduce palatability due to fishy odor and perceptibly discoloration. Other researchers report that wheat loss with 3% or less infected kernels is unaffected in palatability and appearance. All agree that 5% makes bread products unacceptable. Grain with a high percentage of infected kernels must be cleaned or mixed to be acceptable (Warham, 1986).

Discussion:

It is apparent (1) from Table 554 that wheat is one of the major crops in the United States (2) from Table 690 that wheat is one of the major exports of the United States and (3) from Table 14 that the United States is the major exporter of wheat.

If Karnal bunt were established in the United States, wheat from infested areas would probably be denied or restricted access in the export market. Wheat from countries free of the KB pathogen would be desired in KB-free wheat-importing countries. Note that the principal wheat importers (Table 14 above) are free of the KB pathogen. The value of the wheat crop would

decline both internationally and domestically. The domestic price decline would occur because wheat denied or restricted access in the international (and national) market would flood the already adequate domestic supply. If market flooding by wheat were to occur, the market value of other feeds would be reduced.

Yield loss in the wheat crop overall would probably be minor; however, individual fields (and farmers) would probably suffer heavy losses.

Loss in quality due to bunted kernels would probably result in dockage fees for some grain.

Increased production costs (see next section) are likely.

Estimate environmental impact if established.

Medium

Literature:

As seed treatments, certain fungicides, which reduce teliospore germination, are effective on seed-associated teliospores. However, no fungicide can eradicate the seed-contaminating inoculums. In addition, even if seed-treatment fungicides were to achieve complete eradication of the KB pathogen on or in infected seed, the fungicides would only provide partial control of the disease in the field because teliospores survive for many years in the soil. Typical of the seed-treatment fungicides which effectively inhibit teliospore germination are the mercurial, pentachloronitrobenzene, triphenyltin hydroxide, and the heavy-metal fungicides containing copper, zinc, and manganese (Smilanick et al, 1987; Warham et al, 1989; Warham, 1986).

Foliar fungicide sprays at the boot stage have been effective in reducing the incidence of bunted kernels; however, the foliar sprays are not totally effective (Smilanick et al, 1987; Warham, 1986).

Soil tillage methods will affect survival of the teliospores. Teliospore survival was 45, 39, and 27 months at 0, 3, and 6 inches (Krishna and Singh, 1983). Therefore, moldboard plowing which buries the teliospores will reduce inoculums. However, conservation tillage is now commonly used, because of the potential for increased crop yields, reduced labor, reduced fuel consumption, and improved control of soil erosion (Gebhardt et al, 1985).

Karnal bunt control is difficult due to the persistence of the teliospores in the soil and the lack of resistant cultivars. Crop rotation has been advocated as a control strategy. Incidence is increased in irrigated fields and reduced in poorly fertilized fields. However, under present conditions of intensive and extensive cultivation of wheat, recommendations involving long rotations, keeping field fallow, or avoiding irrigation and fertilization do not appear to be feasible (Joshi et al, 1983).

Discussion:

It is possible that there will be increased use of seed-treatment fungicides effective against the KB pathogen, at least in areas where the pathogen is just introduced or threatening. Several of these seed-treatment fungicides have considerable environmental impact. However, in areas where the pathogen is well established, seed treatment fungicides will have little use because the inoculum for KB is primarily teliospores in or on the soil.

It is possible that there will be increased foliar spraying of wheat with fungicides. Because (1) foliar spraying increases production costs, and (2) the disease only appears at economic threshold levels in certain years, foliar spraying would probably not be favored.

Because methyl bromide fumigation was very effective when used in wet soil (Hoffman, 1986), there may be increased soil fumigation. However, soil fumigation will probably not be used due to low crop value, increased production cost, and sporadic disease appearance.

Where the pathogen becomes established, there will probably be increased use of moldboard plowing for wheat crops. If conservation tillage practices are abandoned, there will be reduced crop yields, increased labor, increased fuel consumption, and increased soil erosion.

Estimate impact from social and/or political influences***High*****Literature:**

There are no wheat cultivars known to be totally immune to infection by the KB pathogen either in India or Mexico; however, cultivars may vary in the number of spikes and kernels that become infected as well as in the proportion of the kernel that is bunted (Royer and Rytter, 1985; Warham, 1988).

Discussion:

There will be demands for the production of resistant cultivars.

There will probably be demands for national quarantines to protect areas in which the pathogen is not established. These demands will be based on (1) fear of the loss of export value, (2) fear of reduced grain quality, and (3) fear of reduced grain yield.

There will probably be demands from KB-free countries to (1) delimit infested areas and (2) establish national quarantines to protect KB-free export areas.

There will possibly be environmental/political concerns over the use of foliar fungicides and persistent seed-treatment fungicides.

V. Pest Risk Potential Rating (low, medium, high) *High*

**Method of calculation is explained on pages 20-22 of the Q37 Implementation Package.*

Definition of Pest Risk Potential Rating:

Low =	acceptable risk – organism(s) of little concern to PPQ (does not justify denied entry or regulation)
Medium=	unacceptable risk – organism(s) or moderate concern to PPQ (Either deny entry or regulate)
High=	unacceptable risk – organism(s) of major concern o PPQ (either deny entry or regulate)

VI. Specific Questions:

1) What effects will the presence of the Karnal bunt pathogen have on wheat exports?

If established in the United States, wheat for export from infested areas could be denied entry to major importers, which are wheat-growing countries. The value of wheat export crop would decline, at least in the area where the KB pathogen is established.

If established in some areas of the United States, quarantines and surveys would be necessary to maintain the quarantine.

2) How fast and how effective would the switch over to disease resistant wheat plants be?

There appears to be some resistance available; however, incorporating the resistance and developing the resistant variety could take years with traditional methods.

3) Will fungicides inhibit when used as seed treatments?

When used as a seed treatment, fungicides are very effective in reducing teliospore germination; however, fungicides cannot eradicate the pathogen. Effective fungicides are fungistatic (inhibitory), not fungitoxic (fungicidal).

4) If the Karnal bunt pathogen is introduced into the United States, is eradication possible?

Eradication might be possible if an isolated field infestation was identified early enough. This might be accomplished by soil fumigation, followed by deep plowing, followed by growth of a nonhost crop for at least five years.

5) Is it reasonable to establish a domestic quarantine on infected wheat-growing areas of the U.S. (when the Karnal bunt pathogen becomes established) in the hopes of slowing or stopping the spread of the pathogen?

It is likely that the pathogen will only be able to establish itself in the warmer wheat-growing areas of the United States. If these regions are separated by geographical barriers, quarantines may be effective indefinitely. If these regions are separated by vast distances, quarantines may be effective for a long period of time. If these regions are separated by limited distances, quarantines may be effective only for a limited period of time if at all.

VI. Summary and Recommendations:

The following are recommended:

If not introduced,

- 1). Maintain the KB quarantine on all wheat imports.
- 2). Maintain an updated action plan to eradicate or quarantine the KB pathogen if introduced.
- 3). Support research on resistant varieties, chemical control, and eradication where the Karnal bunt pathogen occurs.

If introduced,

- 4). Conduct surveys to determine distribution.
- 5). Establish and maintain national quarantines to restrict the distribution.
- 6). Warn the wheat industry when the KB pathogen is established in the United States and that domestic quarantine action by the Agency may not be effective or acceptable to importers.
- 7). Recommend that the wheat industry and breeders commence efforts to develop resistant varieties.

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